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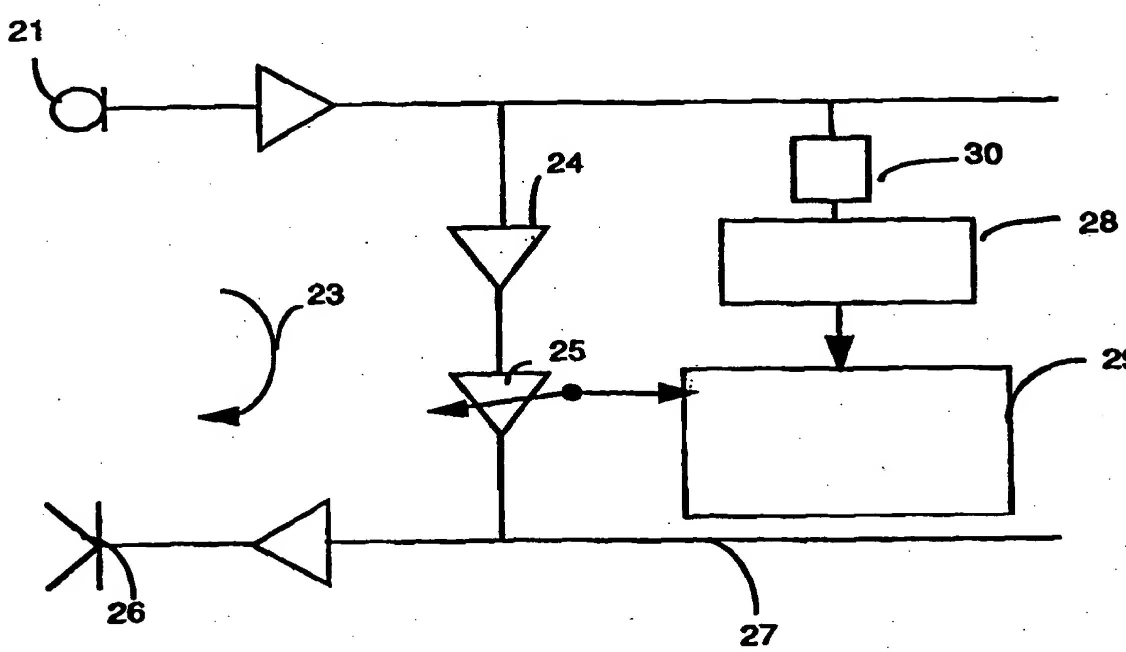

(57) Abstract

A method of adjusting listener sidetone in a handset is provided. Measured ambient noise level of the handset microphone signal is compared against a predetermined threshold. The sidetone level is adjusted by a predetermined amount in response to whether the measured ambient noise level received at the handset microphone is higher or lower than the predetermined threshold.

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METHOD AND APPARATUS FOR LISTENER SIDETONE CONTROL

Field of the Invention

This invention relates to sidetone control in a telephone apparatus and more particularly, to a method of reducing listener sidetone in a noisy environment.

Background of the Invention

Sidetone is defined as a small amount of transmitter signal which is fed back into the talker's receiver. A small amount of sidetone is desirable in the telephone so that the user can hear his or her own voice and therefore determine how loudly to speak.

The sidetone must be at a proper level. Too much sidetone will cause a person to speak too softly for good reception by the far-end party. Conversely, too little sidetone will cause a person to speak so loudly that it may sound like a yell at the other end.

Unfortunately, the introduction of sidetone has been found to be problematic in an environment where ambient noise is high. Local ambient noise, such as generated in noisy road intersections, airports, factory floors etc., is coupled into the receiver channel by way of the sidetone path. The louder the ambient noise, the more difficult it is for the telephone user to hear

the other party's voice. Users complain that they "can't hear" the far end talker under these conditions. To minimize this, it is desirable to reduce the noise fed back through the sidetone path by lowering sidetone loudness. This, however, should only be done in high noise environments, since a nominal sidetone level is required for user comfort in quieter environments.

The amount of ambient noise fed back to a user via the sidetone path in a telephone set is referred to as Listener Sidetone Rating or LSTR. Specifications for different telephone systems typically require that LSTR be greater than 15 dB. Unfortunately, most handset terminals do not meet this requirement. In high noise environments, sidetone levels can be reduced since the user will or should speak louder.

The need therefore exists for a method and apparatus for controlling and reducing listener sidetone in a telephone apparatus.

Summary of the Invention

It is therefore an object of the present invention to provide a method of dynamically reducing listener sidetone according to the noise or ambient noise level detected at the handset microphone.

Another object of the present invention is to provide a method and apparatus for controlling listener sidetone wherein if the noise level is

sufficiently high, a loss is inserted in the sidetone path to improve LSTR performance.

According to an aspect of the present invention, there is provided a method of adjusting listener sidetone comprising the steps of:

measuring the ambient noise level of a received input signal;

comparing the measured ambient noise level against a predetermined threshold; and

adjusting the sidetone level by a predetermined amount in response to whether the measured ambient noise level is higher or lower than said predetermined threshold.

According to another aspect of the present invention, there is provided a method of adjusting listener sidetone in a handset, comprising the steps of:

measuring the ambient noise level of the handset microphone signal;

comparing the measured ambient noise level against a predetermined threshold; and

adjusting the sidetone level by a predetermined amount in response to whether the measured ambient noise level received at the handset microphone is higher or lower than said predetermined threshold.

Brief Description of the Drawings

Fig. 1 is a schematic diagram illustrating generally how sidetone is generated in a circuit of the prior art;

Fig. 2 is a schematic diagram illustrating the basic elements of a controllable sidetone/LSTR path according to an embodiment of the present invention; and

Fig. 3 is a flow diagram illustrating the listener sidetone controlled algorithm according to a preferred embodiment of the present invention.

Description of the Preferred Embodiment

Referring now to Figure 1, we have shown a basic schematic diagram illustrating how sidetone is provided in a typical telephone handset. The telephone handset is depicted by microphone 11 and receiver 12. A sidetone path 13 is established between the microphone and receiver ends of the handset. Sidetone loss is inserted in the sidetone path by means of an attenuator 14. The attenuator 14 is typically a resistive voltage divider network but it could also be an operational amplifier. A predetermined adjustment is made to attenuator 14 to fix the level of the sidetone received at the receiver 12. For users, the sidetone is fixed at one value for all conditions, thus LSTR is also fixed for all room noise conditions.

Shown in Figure 1 is a network echo path 15. This echo occurs at network interfaces such as the four-two-wire hybrid in an analog telephone

set or the point of interconnect of a wireless phone network into the telephone network for example. When the delay in this echo path 15 is very short, i.e. less than 20 milliseconds, it will sound like sidetone to listeners. When the delay is very long, i.e. greater than 20ms, this echo disrupts normal communication. This path must therefore be eliminated. Elimination of the network echo signal is accomplished using echo cancellation techniques either in the telephone terminal or within the telephone network. These techniques are well known to those skilled in the art. Since it is assumed that this echo has been effectively eliminated, the network echo 15 is not shown in remaining figures.

Referring now to Figure 2, we have shown the basic elements forming part of the present invention and, in particular, the method and apparatus for controlling sidetone/LSTR paths. As in the embodiment of Figure 1, a fixed sidetone level loss is introduced in the sidetone path 23 by means of a fixed attenuator 24. However, with the apparatus of the present invention, the overall sidetone level loss introduced in the sidetone path 23 is dynamically adjusted according to the ambient noise level measured at the microphone 21. The overall sidetone level loss introduced in the sidetone path 23 is achieved using a fixed attenuator 24, providing a fixed sidetone level loss, and a dynamically variable attenuator 25, providing a variable sidetone loss. Typically, the variable attenuator 25 is implemented using a programmable

loss amplifier, which is controllable via a micro-controller serial interface or an analog DC voltage.

In order to determine the amount of additional sidetone loss to be introduced in the sidetone path, the level of ambient noise introduced at the microphone 21 needs to be estimated. The output signal 22 of the microphone 21 is converted from to a digital signal format via the analog-to-digital converter 30. The ambient noise picked-up at microphone 21 is estimated by means of a microphone noise estimator 28. This is done by appropriately discriminating noise from speech so that a true ambient noise level can be estimated. Noise estimation techniques are well known to those skilled in the art. For example, a classic noise estimator consists of a full-wave rectifier followed by slow attack and fast decay processing of the signal.

Although the embodiment shown in Fig. 2 makes use of a microcontroller based implementation, the invention described herein can also be implemented using an analog implementation to carry out the estimation of the ambient noise and the LST algorithm.

In addition, although the illustrated embodiment is implemented in an analog telephone set, the circuitry can be adapted to operate with a digital telephone set. In this case A/D and D/A converters would be used between the transducers and the network.

As indicated above, the microphone noise estimator 28 is used to estimate the ambient noise levels picked-up at the microphone. The LST controller 29 makes use of the estimated noise level to determine how much loss is to be inserted in the sidetone path. In the sidetone path, the variable attenuator 25 is then adjusted according to whether additional sidetone level loss is increased or decreased according to the computations made by the LST controller 29. The insertion or removal of additional sidetone loss is done at rates that cause the least noticeable amount of "noise pumping" or other audio artefacts, but keeps LSTR performance optimized for changing environmental noise. The rate of insertion or removal of the additional sidetone loss is also referred to as the attack and decay rates of sidetone loss.

As indicated earlier, the sidetone path 23 also includes a fixed sidetone level provided by attenuator 24 which is present to ensure that nominal sidetone levels are available for normal call conditions and provides a fixed loss in the sidetone path from which to start the listener sidetone control. This fixed loss is non-dynamically adjusted to optimise the best case sidetone.

In operation, if the handset is used in a noisy environment, the microphone noise estimator is used to determine the ambient noise level present at the microphone 21. If the noise level is sufficiently high, an additional amount of sidetone loss is inserted in the sidetone path to improve LSTR performance. If noise levels are sufficiently low, the additional amount

of sidetone loss is removed in the sidetone path to optimize sidetone performance.

Referring now to Figure 3, we have shown a flow diagram illustrating how the LST controller monitors microphone noise levels to adjust the sidetone loss level of the sidetone path. Upon initialization 30, the attack and decay timer values are set to predetermined values, block 31. As a first step to the LST control process block 32, the microphone noise level is retrieved from the microphone noise estimator 28 of Figure 2. The computed microphone noise level is used to determine the need for adjusting sidetone path loss. At box 34, if the microphone noise is less than a predetermine threshold, the target sidetone loss is computed to remain at a standard base level, block 35. That is, no additional sidetone loss is the target for the sidetone path. However, if the microphone noise is greater than the threshold, a target sidetone loss is computed, block 36, according to a predetermined level plus the standard base sidetone loss.

At block 37, depending on the result of the previous operations, if the target sidetone loss is less than the current sidetone loss, then the sidetone loss is reduced at a predetermined rate as determined by the decay timer, block 38. If the target sidetone loss is greater than the current sidetone loss, then the sidetone loss is increased at a predetermined rate as determined by the attack timer, block 39.

The sequence of blocks 38-40-41/43-45-46/48 shows the sidetone loss decay or sidetone loss removal process. The decay timer is decremented in 38 by one when the LST algorithm is in the decay process. If the decay timer has not expired in block 40, the algorithm is exited in box 41. When the decay timer has expired, the current sidetone value is reduced by one step and the decay timer is re-initialized as shown in box 43. In box 45, the current sidetone setting is then compared to the target setting. If the current setting is less than the target setting, the current setting is made equal to the target setting in box 46 which means the sidetone has now stabilized. If the current setting is not less than the target, then the LST algorithm is exited in box 48 and the decay process will continue on the next iteration of the algorithm until the sidetone loss has reached the new value.

The sequence of blocks 39-42-41/44-47-46/48 shows the sidetone loss attack or sidetone loss insertion process. The attack timer is decremented in 39 by one when the LST algorithm is in the attack process. If the attack timer has not expired, the algorithm is exited in box 41. When the attack timer has expired, the current sidetone value is increased by one step and the attack timer is re-initialized as shown in box 44. In box 47, the current sidetone setting is then compared to the target setting. If the current setting is greater than the target setting, the current setting is made equal to the target setting in box 46 which means the sidetone has now stabilized. If the current setting is

not greater than the target, then the LST algorithm is exited in 48 and the attack process will continue until the sidetone loss has reached the new value.

The sidetone loss characteristic versus the microphone noise level and the rate of insertion and removal of sidetone loss is based on subjective preference and can be determined by means known to those skilled in the art. As an example, one possible listener sidetone reduction characteristic versus room noise may be a linear change in sidetone versus room noise i.e. for every one decibel change in room noise, the sidetone is changed by the same amount.

In one embodiment of the invention, the method described herein is used to adjust listener sidetone at a wireline telephone handset such as used in a pay telephone or in a wireless set. However, the method can also be applied to headsets, whereby the use wears a microphone/ speaker device over their head. Similarly, the invention can be implemented via a line interface card or other network device as opposed to the user's terminal. In this case, the line interface card would adjust the listener sidetone perceived by the end user.

WHAT IS CLAIMED IS:

1. A method of adjusting listener sidetone comprising the steps of:

measuring ambient noise of a received input signal;

comparing the measured ambient noise level against a predetermined threshold; and

adjusting the sidetone level by a predetermined amount in response to whether the measured ambient noise level is higher or lower than said predetermined threshold.

2. A method as defined in claim 1, wherein said ambient noise level is measured by discriminating noise from speech received at said input signal.

3. A method as defined in claim 2, wherein said ambient noise level is measured using a noise estimator.

4. A method as defined in claim 3, wherein said noise estimator discriminates noise from speech by rectifying said input signal followed by a slow attack and fast decay processing of the signal.

5. A method as defined in claim 1, wherein if said ambient noise level is less than said predetermined threshold, a target sidetone loss is computed to remain at a standard base level.

6. A method as defined in claim 5, wherein if said ambient noise level is greater than said predetermined threshold, a target sidetone loss is computed according to a predetermined level plus the standard base sidetone loss.

7. A method as defined in claim 6, wherein if said target sidetone loss is less than a current sidetone loss, then the sidetone loss is reduced at a predetermined rate as determined by a decay timer.

8. A method as defined in claim 6, wherein if said target sidetone loss is greater than a current sidetone loss, then the sidetone loss is increased at a predetermined rate as determined by an attack timer.

9. A method as defined in claim 1, wherein said input signal is received at a handset microphone.

10. A method as defined in claim 9, wherein said handset is a wireline handset.

11. A method as defined in claim 9, wherein said handset is a wireless handset.

12. A method as defined in claim 1, wherein said input signal is received at a headset microphone.

13. A method as defined in claim 1, wherein said input signal is received at a network device.

14. A method as defined in claim 13, wherein said network device is a line interface card.

15. An apparatus for adjusting listener sidetone, comprising:

a noise estimator for measuring ambient noise level received from an input signal;

means for comparing the measured ambient noise level against a predetermined threshold; and

a listener sidetone controller for adjusting the sidetone level by a predetermined amount in response to whether the measured ambient noise level is higher or lower than said predetermined threshold.

16. An apparatus as defined in claim 15, wherein if said ambient noise level is less than said predetermined threshold, a target sidetone loss is computed to maintain a standard base level.

17. An apparatus as defined in claim 16, wherein if said ambient noise level is greater than said predetermined threshold, a target sidetone loss is computed according to a predetermined level plus the standard base sidetone loss.

18. An apparatus as defined in claim 17, wherein if said target sidetone loss is less than a current sidetone loss, then the sidetone loss is reduced at a predetermined rate as determined by a decay timer.

19. An apparatus as defined in claim 17, wherein if said target sidetone loss is greater than a current sidetone loss, then the sidetone loss is increased at a predetermined rate as determined by an attack timer.

20. An apparatus as defined in claim 15, wherein said input signal is received at a handset microphone.

21. An apparatus as defined in claim 1, wherein said input signal is received at a handset microphone.

22. An apparatus as defined in claim 21, wherein said handset is a wireline handset.

23. An apparatus as defined in claim 21, wherein said handset is a wireless handset.

24. An apparatus as defined in claim 15, wherein said input signal is received at a headset microphone.

25. An apparatus as defined in claim 15, wherein said input signal is received at a network device.

26. An apparatus as defined in claim 25, wherein said network device is a line interface card.

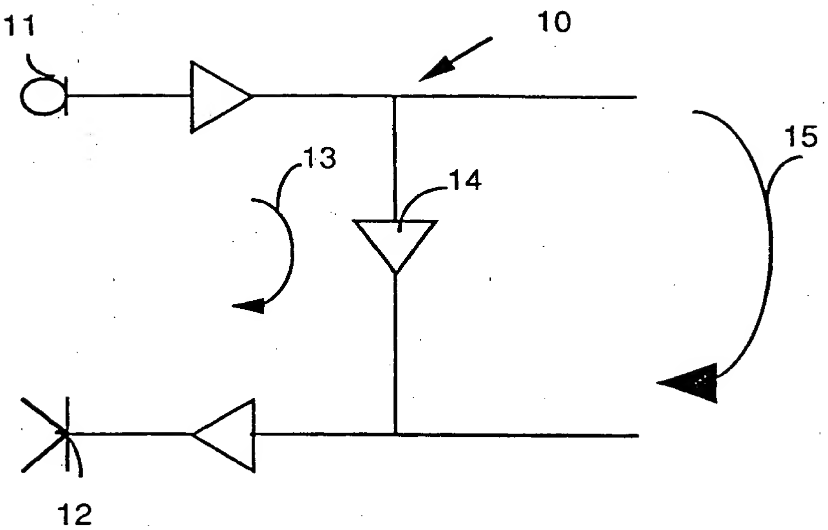

Fig. 1 Prior Art

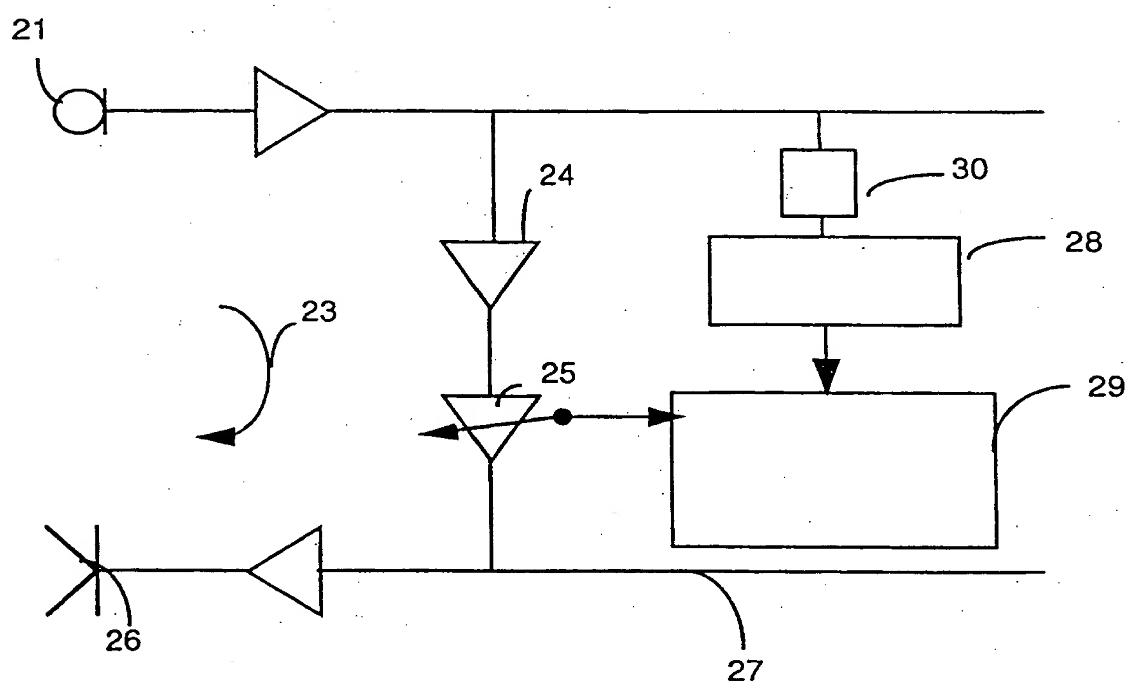

Fig. 2

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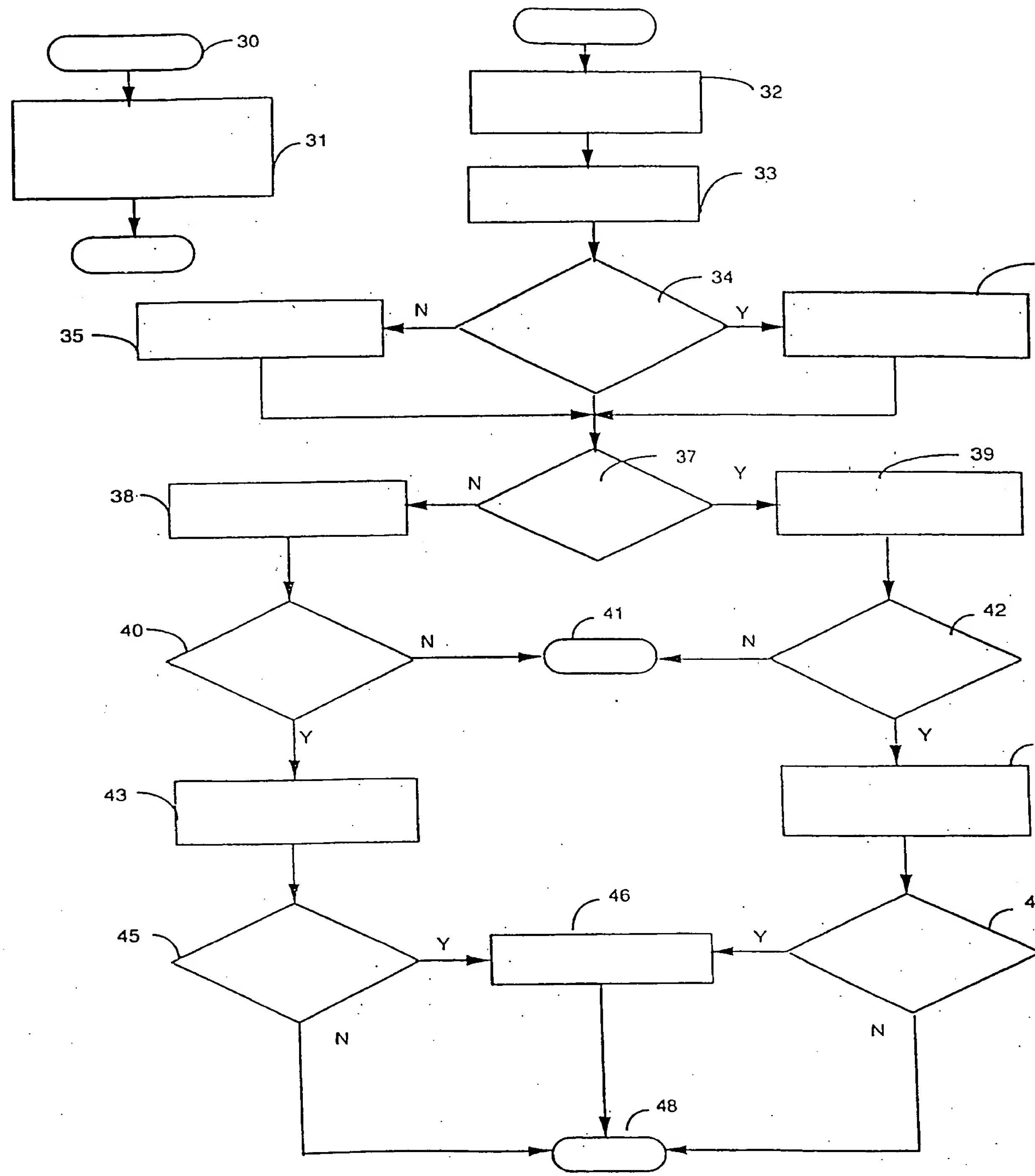
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Fig. 3

INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/CA 98/00674

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04M1/58 H04M1/60

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 361 884 A (STC PLC) 4 April 1990 see column 2, line 47 - column 3, line 37 see column 4, line 17 - line 31 see figure 4 ---	1-10, 15-22
X	PATENT ABSTRACTS OF JAPAN vol. 009, no. 315 (E-365), 11 December 1985 & JP 60 148259 A (NITSUPOU TSUUSHIN KOGYO KK), 5 August 1985 see abstract ---	1-3,9, 10,15, 20-22
X	US 5 640 450 A (WATANABE OSAMU) 17 June 1997 see column 1, line 52 - line 64 see column 2, line 32 - line 38 see figure 1 --- -/--	1,9,10, 15,21,22

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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18 November 1998	26/11/1998

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 317 (E-1382), 16 June 1993 & JP 05 030177 A (KOKUSAI ELECTRIC CO LTD), 5 February 1993 see abstract	1-3,9, 10,15, 20-22
A	PATENT ABSTRACTS OF JAPAN vol. 096, no. 001, 31 January 1996 & JP 07 240782 A (SONY CORP), 12 September 1995 see abstract	1-3, 9-11,15, 20-23
A	GB 2 307 617 A (NOKIA MOBILE PHONES LTD) 28 May 1997 see abstract see page 1, line 21 - page 2, line 16 see page 4, line 6 - line 15 see figure 1	1-3, 9-12,15, 20-24

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/CA 98/00674

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